

How Many Dvaravati Kingdoms? Locational Analysis of First Millennium A.D. Moated Settlements in Central Thailand

Karen M. Mudar

*Repatriation Office, National Museum of Natural History, MRC 138, NHB,
Smithsonian Institution, Washington, DC 20566*

Received December 5, 1996; revision received November 17, 1997; accepted June 22, 1998

Locational information about moated settlements derived from examination of aerial photographs of central Thailand is used to assess the degree of regional integration and political centralization during the sixth to ninth centuries A.D. around the Bay of Bangkok. A consideration of settlement size hierarchy, rank-size distribution, and geographical location suggests that the moated settlements were integrated into a single regional economic system by the end of the time under consideration. While it is argued that the moated settlements represent remnants of administrative hierarchy, it is unclear from the current data whether a single state-level polity or a series of smaller competing polities were present. Further investigation is needed to comprehend how the inhabitants of this region, who shared a common material culture and symbolic system, conceptualized their political relationships. © 1999 Academic Press

Key Words: Southeast Asia; locational analysis; state-level polities.

INTRODUCTION

Much research focused on pre-modern complex polities in Southeast Asia has been carried out over the last 100 years (Christie 1990:39). Despite these efforts, however, there has been little consensus on the time and the factors contributing to the appearance of large and hierarchically organized polities in this region. The immediate antecedents of powerful polities such as Angkor, Pagan, and Srivijaya, which dominated the social landscape of Southeast Asia in the early second millennium A.D., are incompletely known (Miksic 1995:55).

This lack of concurrence can be partially attributed to the history of research in Southeast Asia. Most of the early investigations of complex polities in Southeast Asia have been within the field of history. These vital pioneering efforts have given us translations of inscriptions (Coedes 1937–1954), maps, and analyses of Chinese texts (Pelliot 1904). Because of the nature

of these data, historians concluded that social complexity came relatively late to Southeast Asia, through the agency of contact with India (Christie 1990:41). Polities that left no records or monumental architecture were largely invisible.

More recent historians have incorporated archaeological information about settlement patterns, agricultural practices, and excavation results into insightful studies of Southeast Asian early complex polities (for examples see Wheatley 1983, Hall 1985, Hagesteijn 1989). Much research on historical period subjects, however, still focuses on iconography and epigraphy (Miksic 1995:55). Because of this focus, it has been difficult to move past early perceptions of an Indianized Southeast Asia (Hagesteijn 1989:2), and to surmount assumptions about the level of complexity of the societies under study.

Fruitful discussion about the emergence of complex polities on mainland Southeast Asia has been limited by the lateness

of the historical data and the paucity of archaeological data for the proto-historic period. Lack of data amenable to testing of archaeological propositions has rendered the subject of early complex polities more one of speculation than analysis (Stott 1992:47). Given this lacuna in the archaeological data, we are fortunate to have locational information about a series of settlements dating to the second half of the first millennium A.D. A careful study of aerial photographs of the Central Plain of Thailand has produced an atlas of moated settlements (Supajanya and Vanasin 1983) that have been generally identified as remnants of the Dvaravati Kingdom, a little known Mon polity, or polities on the shores of the former extent of the Bay of Bangkok (see Fig. 1).

In the absence of radiocarbon dates, Dvaravati sites are identified by the presence of distinctive high-fired earthenware pottery (Bronson 1976, Indrawooth 1985), styles of statuary (Lyons 1979), and decorations on public buildings (Krairiksh 1975). Moated settlements characterized by Dvaravati material culture develop at the beginning of the 6th century A.D. and appear to have maintained a separate cultural identity until the region was incorporated into the Khmer empire during the 10th century (Briggs 1951). Writing systems, honorifics (de Casparis 1979), and art styles indicate that there was extensive contact with India, but the role of South Asia polities in the growth of moated settlements on the Central Plain remains poorly understood.

The widespread distribution of similar stylistic elements, architectural features, and shared writing and symbolic systems throughout the Central Plain does not necessarily indicate the presence of a single integrated regional polity. Renfrew (1975) and others (in Renfrew and Cherry 1986) point out that peer polities also exhibit shared cultural features as a result of extended interactions. Within the context

of this study, characteristics of material culture known as "Dvaravati" identify settlements that were concurrently occupied. Characterizing sites as Dvaravati does not imply, within the context of this study, that they were part of a single political system.

Although Dvaravati sites are known from other regions of Thailand (see, for example, Saraya 1992), this locational study focuses on settlements on the Central Plain. The data are limited, consisting only of site location and site size. General dates for settlement occupation given by the authors of the atlas are sometimes inferred by the presence and configuration of the moats, whether rectangular, oval, or irregular, themselves. Large and well-known sites that have been repeatedly excavated provide information about the dates of occupation, but the smaller sites remain unexamined by ground survey. Within these constraints, however, it is possible to test basic propositions about the organization of settlements on the Central Plain of Thailand during the first millennium A.D. Even though the settlement distributions are a static accumulation of dynamic political and economic processes that took place over hundreds of years, this study identifies key developments and defines areas for future research. Through quantification of meaningful variables (Bayard 1992), this study takes steps in developing models for the explanation of the development of complex polities in Southeast Asia.

METHODS

The bulk of the data for this analysis comes from a study by Supajanya and Vanasin (1983), who, using aerial photographs, identified 63 moated settlements on the Central Plain of Thailand (see Ap-

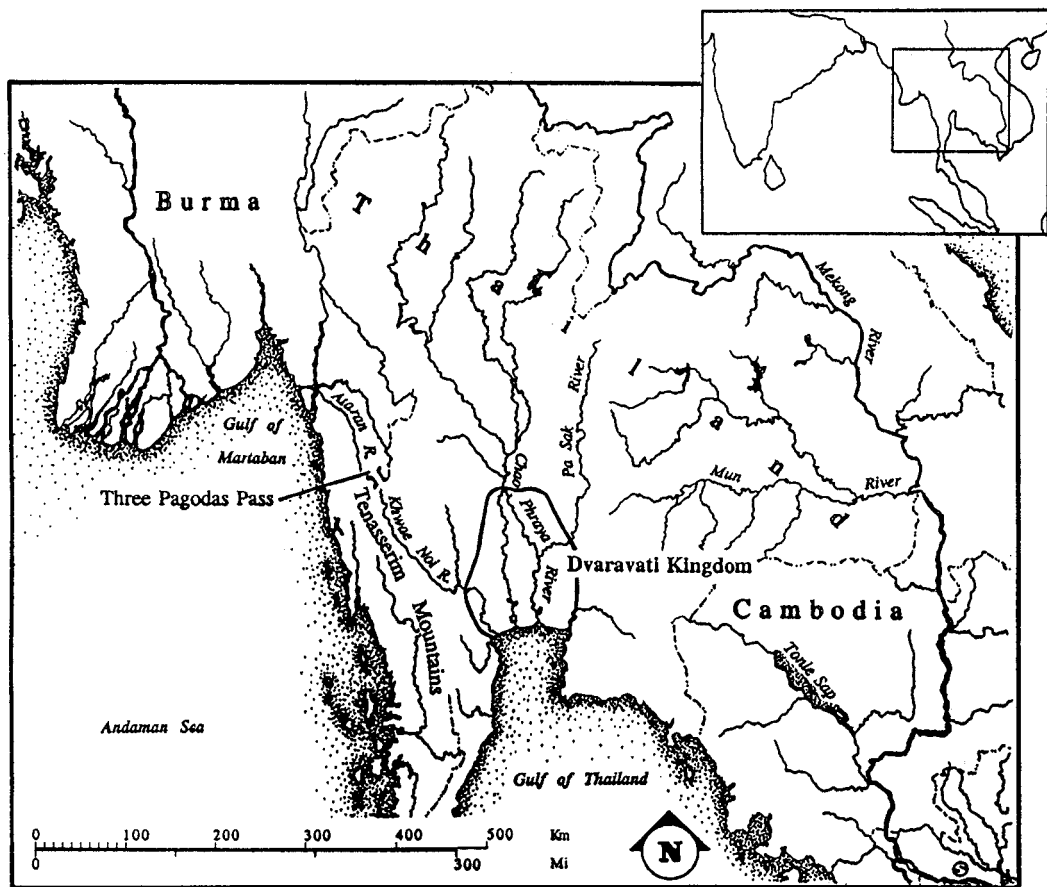


FIG. 1. Map of Southeast Asia.

pendix I, Fig. 2).¹ Two sites identified by Supajanya and Vanasin as dating to a later time period are excluded from this study. Two sites in Lopburi Province were added to the catalog of sites. One, KS 53 (11.7), was identified through field survey in the Lam Maleng Valley (Mudar 1993). The other, Tha Khae (11.3), has been largely destroyed by caleche quarrying activities. Ciarla (1992) identified traces of moats that he dated to the Dvaravati Period through site inspection. Moats were not

evident on the aerial photographs examined by Supajanya and Vanasin. This settlement has been included in the sample of settlements examined for this study.

In addition to identifying and mapping moated settlements from aerial photographs, Supajanya and Vanasin also reconstructed the coastline of the Bay of Bangkok at the time of occupation of the moated settlements. During the sixth century, the sea level was appreciably higher and the shallow bay extended inland many more kilometers than at present, creating an irregular shoreline with numerous peninsulas. As a result of this careful study, it is possible to measure the

¹ To enable the interested reader to examine the original data, the site numbering system used by Supajanya and Vanasin is retained throughout this discussion.

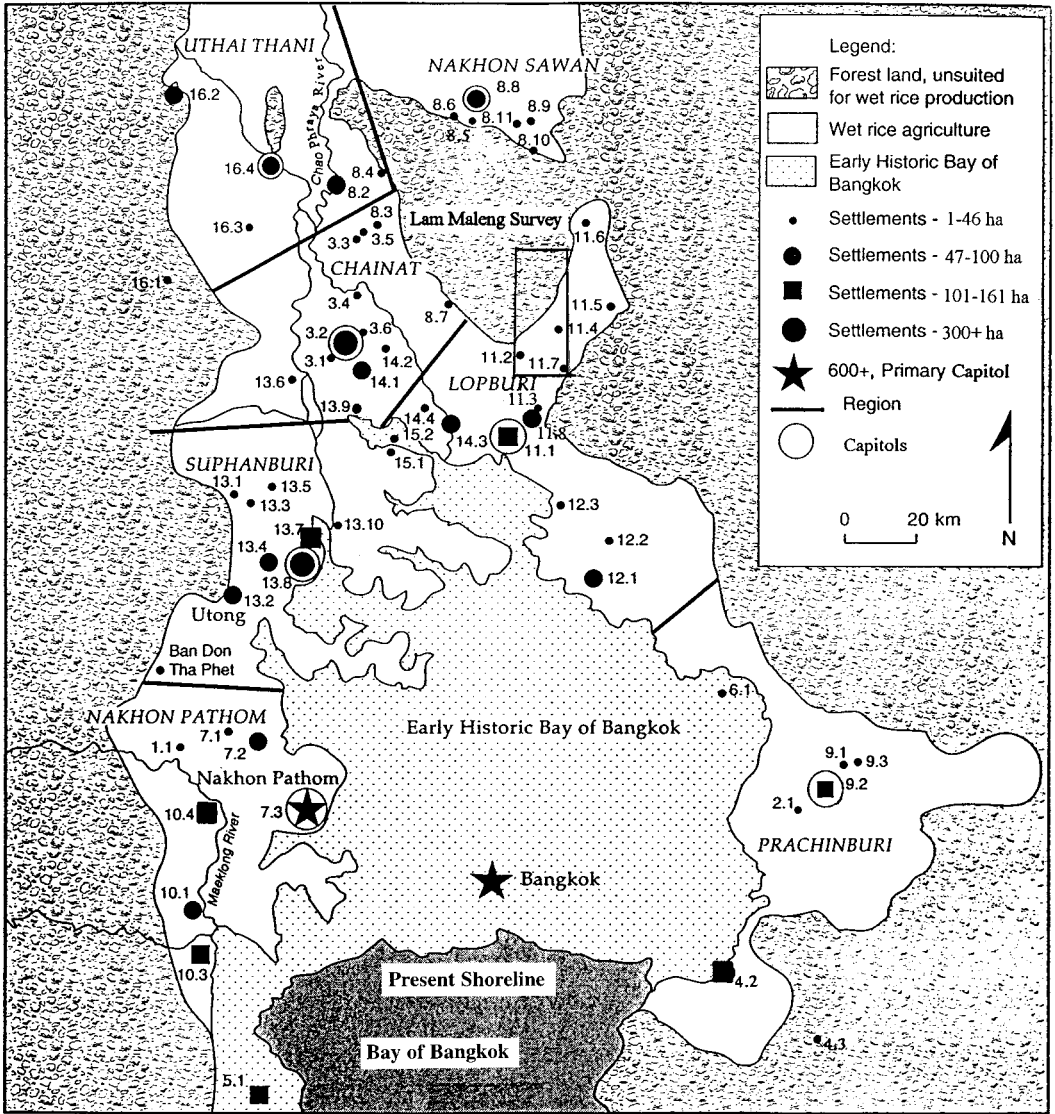


FIG. 2. Moated settlements on the Central Plain of Thailand dating to the first millennium A.D.

distance from settlements to shoreline, distance between settlements, and area enclosed by moats. All of the moated sites in this sample are completely surrounded by a single circular or irregular moat. Walls or ramparts, while known to be present on at least some of the sites, have not been consistently recorded and, as a result, are not used here as an indication

of site function. The most consistently recorded variable for classification was settlement location and moat presence. These data are used here to examine questions of social and economic organization of moated settlements on the margins of the Bay of Bangkok.

In using these data a number of assumptions were made:

1. Although Supajanya and Vanasin may not have identified the northern limits of the settlement distribution, I assume that most, if not all, of the moated settlements on the lower Central Plain were identified. The moated communities, however, represent only a portion of the total settlement system, as recent survey has identified non-moated settlements as well (Thai Fine Arts Department 1988; Mudar 1993, 1995).

2. Little excavation has been conducted at moated settlements to examine spatial patterning of habitation within the moats or to identify habitation outside the moated perimeter. I assume that the relative proportions of public and private space remained relatively constant among all the settlements. I also assume that the relative proportions of habitation inside and outside the moats remained constant for all sites. The areas encompassed by the moats, therefore, provide a relative, if not absolute, measure of population size and can be used for comparative purposes.

3. Although dating of these settlements is not precise at this time, I assume that all sites examined in this study were occupied by the end of the time period under consideration here. Supajanya and Vanasin provided some information about site dates in their catalog; additional information was secured for the best known sites (Quaritch-Wales 1969; Thai Fine Arts Department 1988). Dvaravati components of moated settlements in Lopburi Province were verified through field reconnaissance and were identified from the presence of characteristic pottery and objects on each site (Mudar 1993). Sites founded during the Ankorian Period can be distinguished from Dvaravati sites by their regular, rectangular moats. Dvaravati moats tend to be circular or irregular in shape (Vallibhotama 1992:123). Several sites with regular moats were included in this study, however, as other sources of information

indicated that they had been occupied earlier as well.

4. I assume that the current limits of wet rice agriculture represent the ecological limits of rainfall-fed rice and that these ecological limits have remained relatively constant for the last 1500 years.

SETTLEMENT CHARACTERISTICS

Moats

Moated sites dating to the first millennium A.D. on the Central Plain of Thailand consist primarily of settlements surrounded by deep ditches and, sometimes, ramparts (Quaritch-Wales 1969). These ditches may have been several meters deep and 25 to 40 m wide (Moore 1988a: 145). There have been a number of classifications proposed to accommodate the variability of Southeast Asian moated settlements (Supajanya and Vanasin 1983, Welch 1985, Vallibhotama 1986, Moore 1988a, 1988b). The purpose of moats surrounding communities in Southeast Asia, however, has not been demonstrated.

Moats may have been used for defense, although Welch (1985:260), in an innovative discussion of moated settlements on the Khorat Plateau, points out that the dry season, which is the most common season for warfare, is also the season when moats are most likely to be empty. He notes, however, that even dry, a ditch at the base of a rampart, perhaps surrounded by a stockade, would be an imposing barrier.

Moats may have been used as a source of aquatic resources, such as fish, turtles, and plants. Welch (1985) suggests that the moats in partially moated sites may actually have been ponds that were excavated for domestic use. They may have also been a source of irrigation water for sprouting beds for transplanted wet rice fields. With few exceptions, moated settlements on the Central Plain were completely surrounded by a single ditch, most

were filled by diverted streams, and they were found primarily on soils suitable for rain-fed wet rice agriculture.

This lack of variability in moat design and location precludes determination of moat function on the basis of attributes or on the basis of correlation with recognizable environmental features. I argue here that, regardless of their purpose, the appearance of moated settlements on the Central Plain of Thailand signals an ability to mobilize manpower for public works. From this it may be suggested that the association of a moat with a particular site indicates a control function for that settlement. While moated settlements represent only the top tiers of settlement hierarchies which demonstrably contained numerous small non-moated sites (Mudar 1993, 1995), I argue that these centers were critical elements in the administrative network. Locational analysis of these moated sites, therefore, is expected to yield information about the economic and political organization of the polity or polities represented by these sites.

Rice Production during the First Millennium A.D. in Central Thailand

There are a number of indications to suggest that moated settlements on the Central Plain during the 6th to 10th centuries A.D. relied on wet rice agriculture. First, with two exceptions, the moated settlements are situated within the limits of wet rice cultivation (see Fig. 2). Second, rice chaff has been identified from bricks in several Dvaravati public buildings (Watabe 1976), which suggests that it was a readily available building material. Third, results of a regional survey in Lopburi Province has shown that there was a shift in settlement location from soils suitable for dry farming to soils suitable for wet rice agriculture by this time period (Mudar 1993, 1995). O'Connor (1995:972) suggests that "floodland" rice farming in

conjunction with house gardening was practiced in the Chao Phraya Basin by about 200 A.D.

Rice may be grown under a variety of regimes, ranging from conditions of extensive inundation to those of dry farming. The association of moated settlements with soils suitable for wet rice suggests that this, rather than dry rice, was used. Wet rice may be sustained by irrigation water from canals or streams or grown in shallow ponds of rainwater retained by a clay substrate. The latter type of agriculture is most prevalent currently on the margins of the Central Plain; it is likely that this type of agriculture was also practiced in the late first millennium A.D.

Two main types of rain-fed wet rice have existed on the Central Plain in the recent past: (1) a broadcast system, in which grain is scattered on prepared ground, and (2) a transplant system, in which rice is sprouted in special beds and transplanted to larger fields (Hanks 1972). There are a number of factors influencing the choice of one system over another, such as the availability of land and labor, control over irrigation, and ease of harvesting. Broadcast rice regimes require more land for the same amount of harvested rice as a transplant system, while transplant systems are characterized by higher labor inputs. Transplant systems are more likely to have smaller catchments, as smaller tracts of land are needed to produce a given amount of rice. On the Central Plain, broadcast methods yield 1111–1976 kg of rice/ha, as compared with almost 2500 kg of rice/ha of transplanted land (Hanks 1972).

The Settlement Hierarchy

The 63 moated communities dated to the second half of the first millennium A.D. identified on the Central Plain of Thailand are distributed from Petburi and Prachinburi in the south to Nakhon Sawan in the north, a distance of 270 km. All but two of the sites were located within

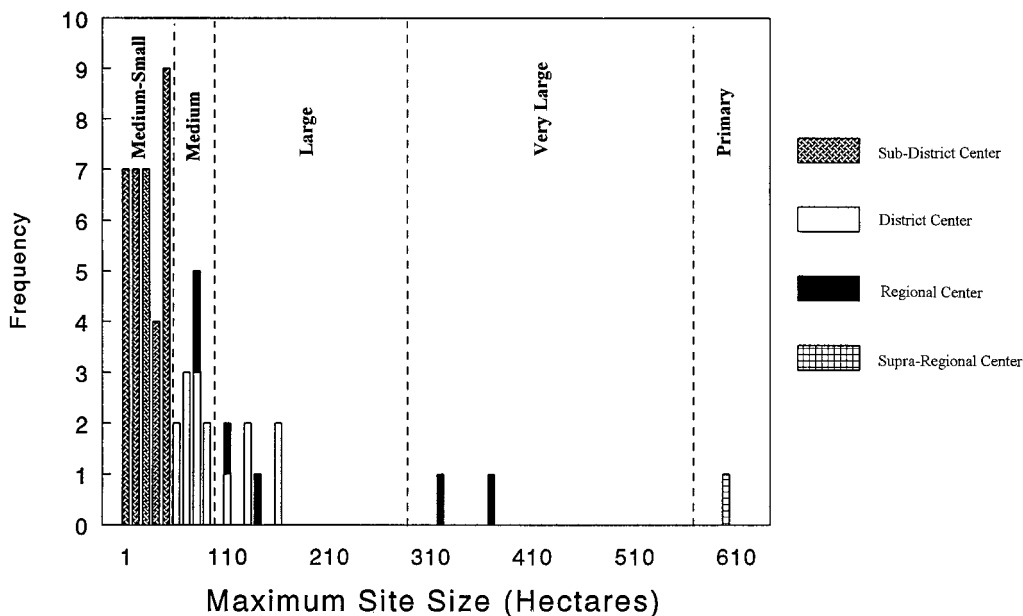


FIG. 3. Settlement size hierarchy of moated settlements in central Thailand.

the present limits of effective rain-fed wet rice agriculture. Soils suitable for growing wet rice paralleled the shores of the Bay of Bangkok and extend north along the upper Chao Phraya Valley. Land on the western side of the Central Plain, however, is in a rainshadow, as the Tennesse-rim Mountains block the southwestern monsoonal rains from land on this side of the Chao Phraya River.

The maximum area enclosed by a moat at each site was used to compute final site size.² The sample was divided

into five categories based on final size (see Fig. 3):

Primary center: The only settlement in this category is Nakhon Pathom (7.3), on the western margins of the Bay of Bangkok. It is the largest site in the sample, measuring 602 ha. Nakhon Pathom also contains the best known and most extensive public buildings associated with this time period (Krairiksh 1975).

Very large moated settlements: This category contains two sites, Suphanburi (13.8) on the western side of the embayment and Praaksrigacha (3.2) on the northern side. They are both about 350 ha in size.

Large moated settlements: There are seven sites in this category, ranging in size from 161 to 101 ha. They are distributed throughout the Central Plain on both sides of the bay.

Medium moated settlements: The 12 moated settlements in this category range in size from 100 to 47 ha. They are distributed throughout the study area.

² Supajanya and Vanasin did not provide maps for several sites whose locations are known. Some deficiencies in the data were rectified by consulting other sources (Quaritch-Wales 1969; Thai Fine Arts Department 1988) to obtain estimates of site size. Settlements for which information about site size could not be found in the literature are retained in Fig. 2, but are not included in any analyses. I assume that the sites for which there was no size information in the general literature were small, and escaped attention. I have, therefore, arbitrarily assigned them a small size (less than 46 ha) in Fig. 2.

Medium small moated settlements: The majority of moated settlements are smaller than 47 ha in size. These 34 sites are also distributed throughout the area.

Further analysis shows, however, that these five categories of sites only partially correspond to the administrative hierarchy.

The Administrative Hierarchy

Position in the administrative hierarchy was provisionally identified on the basis of settlement location as well as size. The administrative center of an area is the largest site in the area, even though it may not be notably larger in terms of region-wide site size categories. The presence or absence of different types of public architecture within the moated habitation areas may be an important indicator of administrative functions, but was not information that was systematically available for all sites in the sample. Further archaeological investigation and identification of different kinds of public architecture may alter assignments within the administrative hierarchy.

Four levels, as indicated by relative site size and location, were identified:

Supra-regional center: There was only one settlement in this administrative position, Nakhon Pathom (7.3).

Regional centers: Seven settlements have been provisionally identified as regional centers: Suphanburi (13.8), Praaksrigacha (3.2), Lopburi (11.1), Pra Rot (9.2), Kok Prassat (8.8), and Ban Dai (16.4). Regional centers were the largest site in each sub-region of the plain, regardless of their absolute size. In this study, Nakhon Pathom is also the regional center for the region of the same name.

District centers: These were defined by size and geographic position in relation to the closest regional centers. There are 15 settlements in this administrative category, ranging in size from 55 to 100 ha.

Sub-district centers: The remaining 34 moated sites in this sample range in size from 45 to less than 2 ha in size.

Three moated settlements [Garung (16.1), Site 16.2, and Site 4.3] were located in regions with limited access to land suitable for growing wet rice on the margins of the Central Plain. They are isolated, and may have been placed to control transportation routes or to exploit resources such as iron ore and stone which are not available on the alluvial plain. These special function sites range in size from 83 to 14 ha.

Position in the site size hierarchy is not congruent with position in the administrative hierarchy (see Fig. 3). Only half of the 10 largest sites were designated regional centers. Two medium-sized sites (9.2, 16.4) were designated as regional centers. Thus, the size range within the upper levels of the administrative hierarchy was fairly large. Bayard (1992:22) notes that a lack of congruence between settlement size hierarchies and administrative hierarchies exists in contemporary Thailand, as well.

Having defined regional centers, Thesian polygons were drawn around them to provisionally identify the regions associated with each center (Hodder and Orton 1976:59) (see Fig. 2). As the regional centers form a linear distribution around the Bay of Bangkok, the perimeters of the regions rely on features of the landscape as well as socially defined boundaries for demarcation. The margins of the embayment form one boundary. The limits of soil suitable for wet rice agriculture form the other. This resulted in seven regions, although the data do not allow us to define the northern limits of the northernmost administrative areas at this time. The regions ranged in size from 3244 to 3352 km², averaging about 3300 km² ($N = 5$), and contained from 7 to 14 moated settlements.

The surprisingly close agreement in size

TABLE 1

Summary Statistics for Administrative Regions in Central Thailand during the First Millennium A.D.
(Excluding Nakhon Sawan and Uthai Thani).

Region	Number of settlements	Area of Capital (ha)	Sum of non-Capital settlement area (ha)	Administrative territory size (km ²)
Chainat	12	315	306	3377
Lopburi	14 (11) ^a	137.5	564 (444) ^a	3417 (2112) ^a
Nakhon Pathom	8	602	613	3360
Prachinburi	7 (6) ^a	103.7	209 (184) ^a	3244 (2901) ^a
Suphanburi	9	366	346	3652
Utapao	4	83	149	1642

^a Numbers in parentheses are adjusted for placement in the Utapao administrative region.

of area assigned to each administrative region can be explained in several ways. It may be related to administrative concern for management of rice lands, as each region, as defined here, has approximately the same amount of land suitable for growing rice. This would assume, however, that rice-growing regimes are the same on either side of the Bay of Bangkok, which may not be the case. The uniformity of administrative area sizes may also be a function of the limits of effective communication within each region. More data are needed to test these propositions.

The regional centers are distributed fairly evenly around the margins of the bay, with an average of 75 km between settlements. This pattern is altered on the eastern side of the bay; there is 130 km between Lopburi (11.1) and Pra Rot (9.2). This distance, unusually large when compared with that between other regional centers, suggests that an administrative regional center has not been recognized. The settlement of Utapao (12.1), 83 ha in size, is situated approximately halfway between Lopburi and Pra Rot and may be a regional center. It would have been, however, associated with a small territorial unit in comparison to other regions, 1642 km², and only one to three other moated settlements (see Table 1). For the purposes of this study, therefore, Utapao

has not been assigned a status as a regional center.

Degree of Regional Integration

The limited data, consisting of evidence for a four- or more tiered settlement hierarchy, uniform territorial sizes, combined with other evidence suggesting that moated settlements shared a similar writing system, religious beliefs, language, and political institutions, are commensurate with definitions of state-level polities. Wright (1977) defines a state as a social formation with a centralized decision-making process that is both externally specialized with respect to the local processes it regulates and internally specialized in that the central process is divisible into separate activities that can be performed in different places at different times. He also suggests that state-level polities are able to coordinate more than three levels of regulatory hierarchy. While the data are inadequate for rigorous testing of propositions concerning state formations on the Central Plain of Thailand, the discontinuous distribution of the sizes of large settlements containing public architecture in the form of moats and the remnants of non-domestic buildings suggests that they represent a sophisticated state-level polity.

It is possible, however, that the scale of the inquiry is incorrect, and that the seven administrative units and their associated settlements defined here represent early state modules (ESMs), as defined by Renfrew (1975), each territory being independently governed. The territorial sizes, as defined here, are almost twice as large as the territories proposed by Renfrew as being characteristic of ESMs. To adequately test these propositions, representative samples of all levels of the settlement hierarchy, both moated and non-moated settlements, are needed.

The question of whether moated settlements on the Central Plain represent a single system or a series of ESMs can be explored by considering the relationship of sites within the system in terms of relative size. The rank-size rule suggests that in a well-integrated regional system a settlement of rank r in a descending array of settlement sizes will have a size equal to $1/r$ of the size of the largest settlement in the system (Johnson 1981:145). If plotted on log-log paper, this dimension yields a straight line with a slope of -1 . This example of complete integration provides a means for evaluating other instances of rank-size distributions.

Johnson (1981) suggests that this characteristic configuration is a function of interacting independent variables that structure site size. He notes that if a random variable y (here considered to be site size) is a product of independent random variables (here signifying degree of regional integration), the distribution of y becomes leptokurtic and skewed (which produces a log-normal line with a slope of -1) as the number of independent variables (regional integration) increases (Johnson 1981:151). In highly integrated systems the size of a given settlement is a conditional function of the sizes of the other settlements (Johnson 1981:152).

There are two interesting deviations to this pattern. One is a convex distribution,

in which the rank-size configuration of the sample lies above a line with slope of -1 . This occurs where there are several larger centers of similar size and is an indication of limited integration between settlements in the sample. It may indicate that the level of regional integration is low; it may also indicate that the sample is composed of settlements from two highly integrated systems that have been pooled. Care is needed when interpreting results of this nature.

Concave distributions, sometimes called primate distributions, occur when the largest site in a settlement system is larger than the sizes the other sites would predict. This may occur when economic competition is minimized for the largest center. In situations of multiple settlement system interaction, this may occur when the largest settlement differentially interacts with settlements in other systems.

The rank-size distribution of moated settlements in this sample suggests that by the end of the first millennium A.D. the Central Plain of Thailand was integrated into a single system as the distribution of sites conforms well to expectations of site-size distribution for a politically and economically integrated system (see Fig. 4). This linear pattern indicates that the settlements were not partially integrated, competing centers and that the largest site, Nakon Pathom, was not an over-sized "primate" center, neither suppressing the growth of other centers nor acquiring resources from a larger system. There is no evidence to indicate that the largest site, Nakhon Pathom, was suppressing growth of other settlements through monopoly of resources or that it was a colony of another polity.

The rank-size distribution of the moated settlements shows rapid fall-off at sizes smaller than about 10 ha. This is characteristic of most rank-size distributions, and is not to be confused with a convex distribution. Johnson (1981:109) suggests that this

indicates the size below which economic viability rapidly decreases.

The lack of a convex pattern suggests that moated settlements on the Central Plain, by the end of the first millennium A.D., were part of a single polity that was politically and economically well integrated. The rank-size distribution indicates that this integration was achieved with the emergence of Nakhon Pathom as the largest settlement. Before adding the second moat that doubled the size the site, Nakhon Pathom was the same size as the second and third ranking sites in the rank-size distribution, which may suggest that they were capitals of three competing polities.

Settlements and Administrative Function

It is possible to test the proposition that moated settlements are administrative centers. Comparisons of moated with non-moated sites suggest that settlements without moats and without administrative functions were limited in their growth potential. Results from settlement survey in the Lam Maleng Valley in Lopburi Province (Mudar 1993, 1995) demonstrate that, although the moated settlements are better known, non-moated sites were a significant component of the late first millennium A.D. settlement system. A total of 32 sites with Dvaravati culture components have been identified in Lopburi Province; 23 were non-moated.

The largest non-moated site in the Lam Maleng Valley was about 12 ha (see Fig. 5 and Appendix II). The size of the moated settlements at which "lower limb fall-off" occurred in the moated settlement rank-size distribution of the larger sample from the Central Plain was 10 ha (see Fig. 4). This suggests that 10–12 ha was the largest that a self-sustaining site without administrative position could grow. Why should this be so? Site growth may be inhibited by the limits of catchment productivity.

The evidence discussed above suggests that rice was the primary grain that underwrote polities on the Central Plain. Whether the rice was broadcast or transplanted is not known. Let us assume, for now, that it was broadcast. On the Central Plain, broadcast methods yield 1111–1976 kg/hectare of land per year (Hanks 1972: 164). Here I use the most conservative estimate of 1111 kg when estimating productivity.

Annual yields are only a rough approximation of the amount of grain available for consumption. Variables such as grain loss, milling loss, and seed saved for planting must be taken into account when estimating community needs. Welch (1985) indicates that grain loss between harvest and milling may be as high as 20%. Milling further reduces weight of grain by 37%. Seed must also be set aside for planting the following year. He suggests that 45 kg/ha is required for broadcast rice. I estimate that approximately 477 kg of milled rice/ha of crop would have been potentially available for consumption on the Central Plain.

Another variable that pertains to absolute estimates of catchment potential is the amount of rice necessary to sustain a person on an annual basis. Durrenberger (1978) suggests that the Shan inhabitants of Thongmaksan consume an average of 327 kg of rice per person per year. Welch (1985) used a consumption rate of 200 kg per year, more than 125 kg lower. MacDonald (1980) used a rate of 1000 kg/year, which is almost certainly too high. Izikowitz (1951) suggests that the average Lamet person consumed 73 kg per year. The differences between the various estimates may be a function of the availability of other foods in the diet. It is, however, difficult to determine whether the inhabitants of the moated settlements would have consumed rather more rice, having limited access to other sources of domestic carbohydrates, or less rice, having access

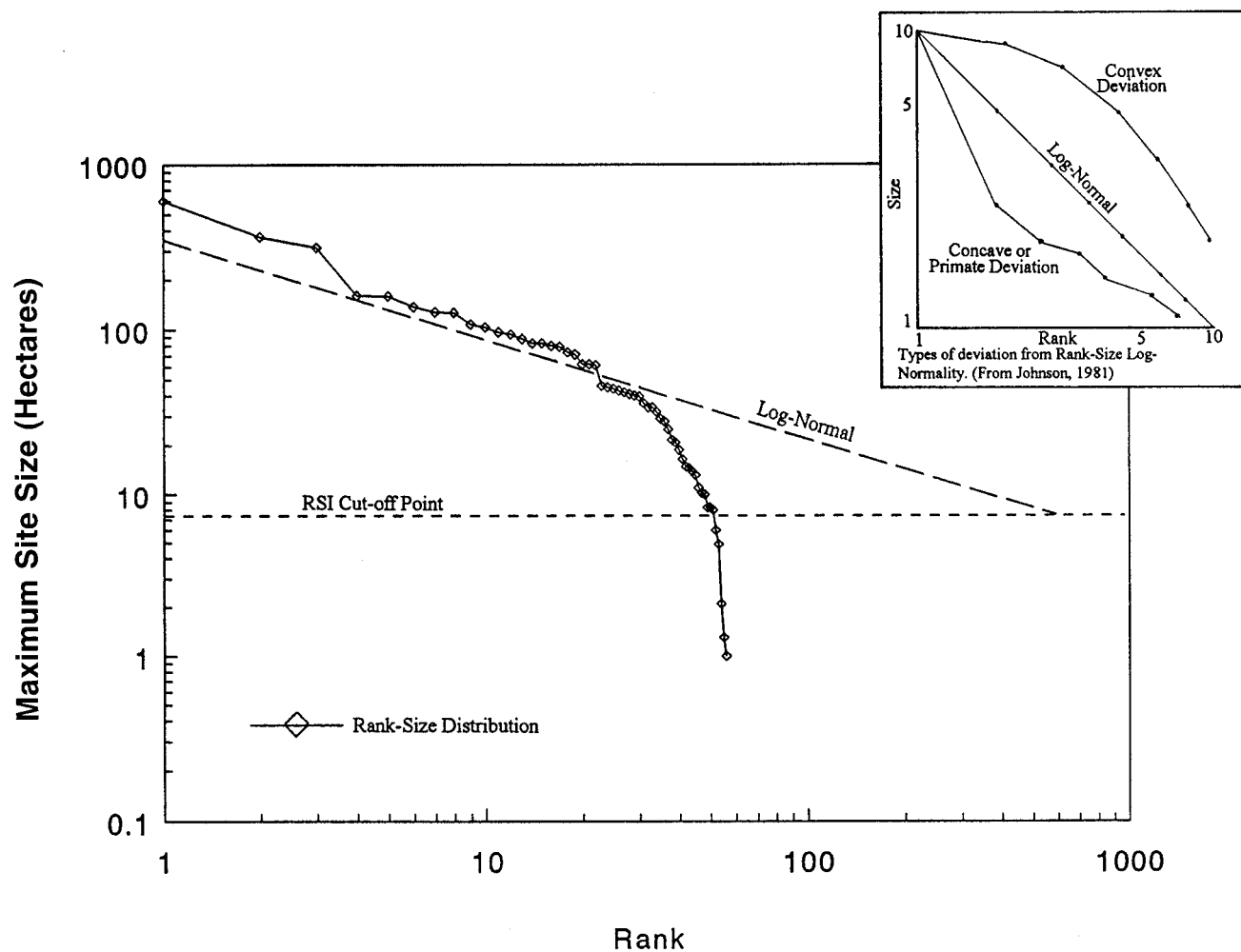


FIG. 4. Rank-size distribution of moated settlements in central Thailand.

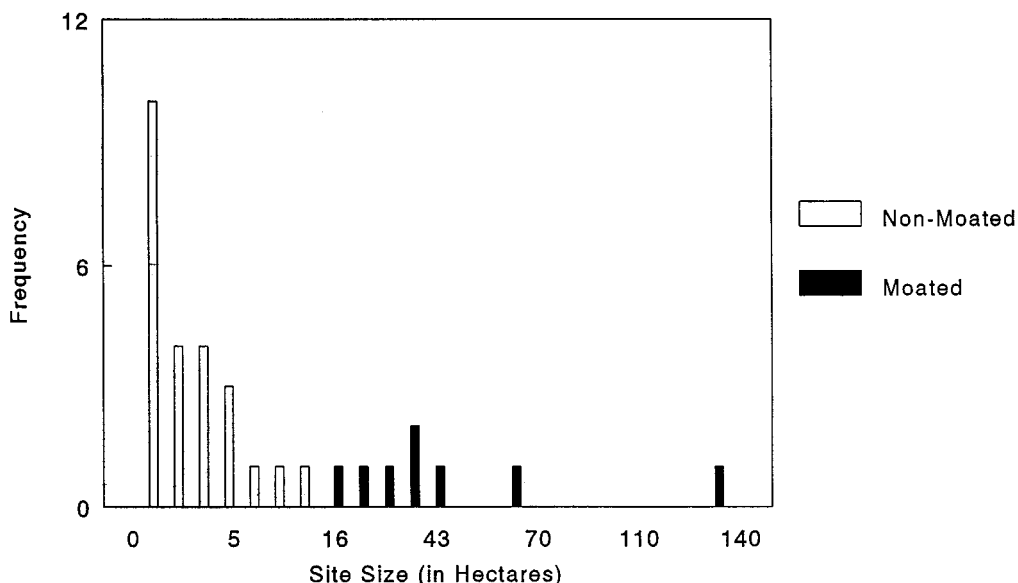


FIG. 5. Settlement size hierarchy of settlements dating to the first millennium A.D. in Lopburi Province.

to wild resources not available to modern peasant communities. Here, following Durrenberger, I use an average estimate of 327 kg of rice per person per year, which is almost a kilogram of rice per day.

Estimates of the amount of rice needed to sustain a settlement on a yearly basis rely on two population parameters: population size and population structure. As population cannot be counted directly, site area provides an approximation. The population of the community undoubtedly expanded beyond the moat perimeter during the occupation of the site. I assume, however, that at construction the moat enclosed the majority of the habitation area. Site area provides, therefore, some measure of population at the time of moat construction.

Population estimates, however, are dependent on estimates of site density. Estimates of the average number of people occupying a hectare of habitation area in Southeast Asia are difficult to assess. Welch (1985) refers to Calder's ethnographic work in northeast Thailand and

uses her figures of 50 and 75 people per hectare of occupation in estimating prehistoric population densities. Macdonald (1980:90) uses a density estimate of 100 people per hectare. He notes that this is approximately the density of people in the present-day village of Ban Na Di, in northeast Thailand. As Wright (personal communication 1992) points out, however, present-day villages may compare poorly with prehistoric settlements. Modern house compounds tend to be large to accommodate mechanized farm machinery, and roads and yards are wide to allow movement of trucks and tractors. In addition, houses built with power tools tend to be larger than houses built entirely by hand, as constraints on the size of trees to be felled and transported are fewer.

Izikowitz (1951) mapped two Lamet villages in the course of his fieldwork. From these maps and his census it is possible to derive a population density estimate of approximately 150 people per hectare of habitation. This figure may be a little high for an average density, as the villages

were situated on a ridge top and were constrained by the narrow summit. The houses, however, were made without mechanized tools, and the pathways did not have to accommodate vehicular traffic. I suggest that a range of 100–150 people per hectare of prehistoric occupation may be more representative than the lower estimates of 50 to 75 people per hectare. In this study I use an average of 100 people per hectare of habitation.

Not all of the enclosed area of a moated settlement would have been devoted to habitation. Excavations at large moated settlements have revealed foundations of large, presumably public buildings, but the extent of moated area devoted to administrative and/or religious buildings and markets is not known. Following Steponaitis (1981:354), I use a figure of 15%. Thus, the area of a site available for habitation, and used for population estimates, is 85% of the total site area.

The proportion of adults in each settlement is a function of the population structure. At present, no cemeteries from this time period have been studied, and no data are available for population structure at moated settlements. Weiss suggests that, assuming a stable population structure, the proportion of individuals between the ages of 15 and 60 in pre-industrial populations ranges between 34 and 58% (Weiss 1973). The exact proportion is dependent on specific birth and death rates, which are not available for this population. I use here the maximum population estimate of 58% adults.

Using estimates of an average of 85 people/ha of total site and a population structure of 58% adults, I estimate that there were 50 adults/ha of habitation, each requiring 327 kg of rice/year for sustenance. I assume here that the other 42% of the population, children under 15 and adults over 60, required less rice, a figure that I have set at 1 kg rice/day. The amount of rice required yearly for a sub-adult or an

elderly person is estimated to be 163 kg, and the amount of rice required to sustain an average population of a hectare of habitation on a yearly basis is 22,055 kg. The amount of rice needed to support a 10-ha community would, therefore, be 220,550 kg.

If broadcast rice planting yields 477 kg of rice/ha for consumption, 492 ha of land, or a circular catchment area with a radius of 1.2 km, is required to support a community of 10 ha. Assuming that some portion of the land is fallowed and devoted to other crops and woodlots for firewood, and that some portion of the rice harvest is given up for taxes, the catchment area required would be even larger. Work by Naroll (1962), however, suggests that there is an upper limit to effective agricultural catchment size, and that most farmers prefer to walk no farther than 2 km to fields. Under the conditions stipulated here, a 10-ha site approaches the largest size that a settlement can easily grow without relying on foodstuffs extracted from the surrounding communities. These conditions may have limited the size of non-moated settlements and suggest that sites significantly larger than this either relied on other communities for some portion of their foodstuffs or used other forms of cultivation, such as transplanted rice.

Under conditions of transplanted wet rice agriculture yielding 1348 kg/ha of consumable rice a 10-ha community would require a catchment area with a radius of approximately 0.8 km, assuming that all the land within this catchment was devoted to rice production. A catchment area with a 2-km (2.13 km, when the habitation area is subtracted) radius could support a community approximately 70 ha in size, assuming that all non-inhabited land within this radius was given over to wet rice.

The results of this exercise suggest that, under conditions of broadcast wet rice cultivation, settlements larger than 10–12

ha were probably not self-sustaining and drew on other communities to support some portion of the population. Under conditions of transplanted rice agriculture, sites had the potential to grow to a larger size, up to 70 ha, but were still limited by effective catchment size. Under either cultivation regime, and both may have been practiced on the Central Plain, the data suggest that some portion of the settlement system was maintained by other communities.

Propositions about the types of wet rice cultivation practiced could be tested by comparing the maximum size of non-moated sites from different parts of the Central Plain. Regions in which agricultural practices have resulted in higher productivity should exhibit larger averages in the maximum site size for self-sustaining communities than regions whose agricultural practices resulted in lower productivity. Unfortunately, data comparable to the Lam Maleng survey in Lopburi Province are not currently available. Glover (1982–1985) reported on a series of non-moated “Early Historic” settlements in Suphanburi and Kanchanaburi provinces, which undoubtedly included components from the 6th to 10th centuries A.D., but did not include site sizes in his descriptions. Data from Lopburi Province suggest that non-moated settlements on the eastern Central Plain were supported by broadcast wet rice; however, on the western plain decreased water supplies may have forced a mix of transplanted wet rice and dry farming of other crops.

EVIDENCE FOR CENTRAL CONTROL OF LOCAL RESOURCES

Span of Control

The above examination of the rank-size distribution of settlement sizes indicates that the degree of regional integration was high by the end of the time period consid-

ered here, congruent with an interpretation of economic and political interdependence. This regional integration was most likely achieved through the development of control apparatus that, among other things, monitored resource allocation. Examination of relationships between the moated settlements may indicate the span of control, one aspect of administrative oversight.

The span of administrative control refers to the number of different kinds of activities monitored and the number of sub-units supervised. Johnson (1981) has found that an administrative unit that supervises a wide range of activities is usually responsible for fewer sub-units than one that is responsible for the supervision of a limited range of activities. Johnson demonstrates that an administrative unit can supervise more people performing a few types of tasks or fewer people performing many different types of tasks. This is a function of the limits on different categories of information that can be efficiently processed by the administrative unit.

If the areas enclosed by the Thessian polygons relate to administrative units we can examine the span of control for each region. If we assume that the proportion of administrative personnel and population density is relatively constant for all sizes of moated settlements, then the ratio of the size of the regional center to the combined area of all the other moated sites in the region can provide us with a relative measure of the span of administrative control.

The number of subordinate moated settlements within each region ranges from 6 (Prachinburi) to 13 (Lopburi). When the ratio of the area of each regional center to the combined area of other communities with administrative functions in the region is computed we see two patterns emerge (see Fig. 6).

On the western and northern margins

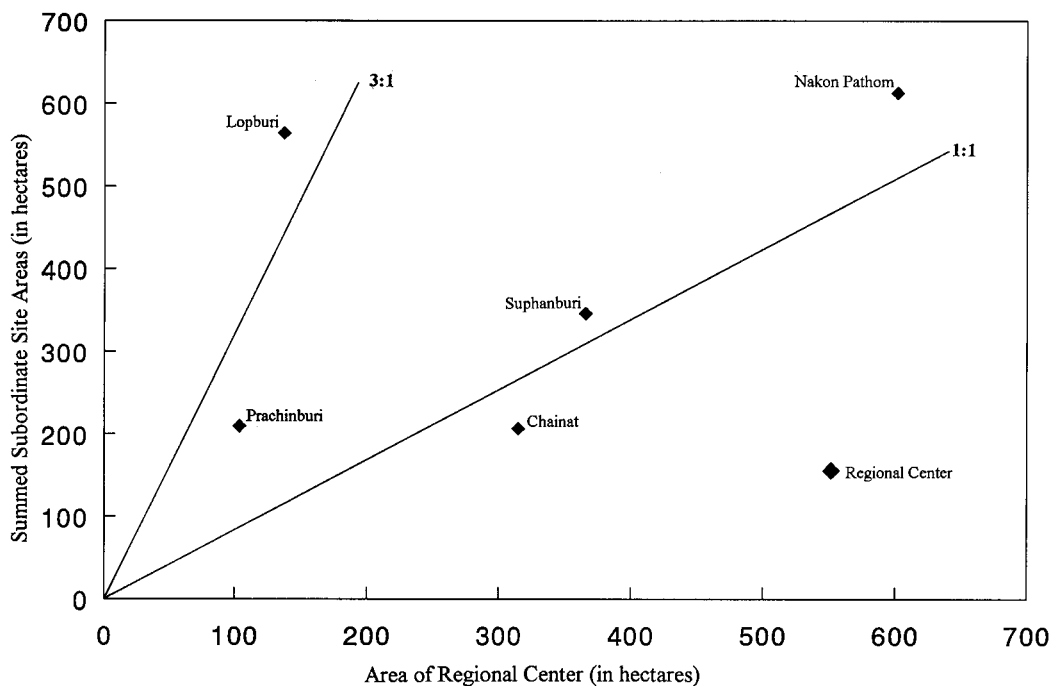


FIG. 6. Ratio of settlement size of each regional capital to summed areas of moated settlements under its administrative control in central Thailand.

of the Bay of Bangkok, this ratio is approximately 1:1. The area of the regional center is approximately equal to the summed areas of all other moated sites within the defining Thessian polygon. If we assume that the site area of the moated settlements can be used as a relative population estimate, and that administrative personnel is a constant proportion at all moated sites, then this ratio suggests that there were a limited number of sub-units supervised by administrative units in the western and northern regions. This ratio further implies that a relatively wide range of activities were supervised.

On the eastern side of the Bay of Bangkok, the ratio of size of regional center to other site areas combined is between 1:2 and 1:4. The ratio for Lopburi region is 1:4. If settlements associated with the Lopburi administrative region are included in the Utapao region the ratio is still high, 1:3. The ratio for Prachinburi

region is 1:2. This suggests that the control hierarchy in these regional centers was responsible for a larger number of sub-units. This ratio also implies that fewer kinds of activities were monitored.

If settlements on the eastern and western sides of the Bay of Bangkok were involved in different modes of rice agriculture, the differences in the span of control may be a reflection of different grain mobilization practices. Hagesteijn (1989:99) suggests that Southeast Asian administrators had difficulty mobilizing grain from constituent settlements. In the rain-shadow areas of the western side of the Bay of Bangkok the relatively rainfall-poor environment may have required greater emphasis on irrigated and transplanted rice regimes. The smaller fields needed for transplanted rice could have been relatively accessible to moated settlements and facilitated supervision of corvée labor.

This system of grain mobilization would

not have been as efficient on the eastern margins of the Bay of Bangkok if settlements there depended on broadcast rice. Large field sizes and distance from settlements may have made mobilization of harvested grain more efficient.

On the eastern side of the Bay of Bangkok slightly higher rainfall would have permitted broadcast rice, as it does today. Administrative offices, finding it difficult to monitor activities of a more dispersed population, may have relied on mobilization of rice, rather than cultivation of reserved fields. Large field sizes and distance from settlements may have made mobilization of harvested grain more efficient. Data from complete regional surveys on the west side of the Bay of Bangkok, comparable to settlement data from the east side (Mudar 1993, 1995), are needed to examine questions of economy and regional organization more closely.

Administrative Territories

Settlement size alone is not necessarily indicative of relative importance in the administrative hierarchy. Catchment size and productivity in relation to site size can also be important variables. In an insightful study, Steponaitis (1981) developed a predictive model of administrative organization based on site size and catchment, and tested it with Formative Period sites in the Valley of Mexico. In particular, Steponaitis examined the relationship between settlement size and agricultural potential. Using these data, he demonstrated that settlement size in combination with other analytical variables provided a better measure of control functions at each settlement than site size alone. Using a measure of catchment productivity, he found that communities with administrative functions tended to be larger than their catchment potential would have predicted. This discrepancy is because a por-

tion of the population at these sites was supported by foodstuffs mobilized from other communities. In his study, catchments were defined as land within a 1- to 2-km radius of the center of the settlement. Graphing sizes against catchment potential allowed Steponaitis to identify the number of administrative levels in the community and examine the organization of control.

Steponaitis' (1981) study of settlement patterns in the Valley of Mexico demonstrated that a complex polity that sustains itself through mobilization of foodstuffs, particularly agricultural products, will exhibit regular relationships between site size and catchment potential, which are partially a function of the administrative hierarchy. The difference between the observed and expected relationships was a means to measure the amount of tribute being extracted, degree of centralization, and identification of settlements with control functions.

In the present study I argue that if there was mobilization of agricultural goods by moated settlements, a regular relationship between moated site sizes and administrative territories should also be evident. To examine the nature of this relationship Thessian polygons were drawn around all of the moated settlements in each region, and the area within each polygon was measured (see Appendix I). The area of each polygon was then plotted against site size (see Fig. 7). There are some differences in the methodology, as Steponaitis measured productivity variation within a constant area, and I assume that productivity is constant on the relatively homogeneous Chao Phraya Plain and measure variation in area associated with each moated settlement. I propose, however, that mobilization of agricultural goods should be evident in a regular relationship between site size and land within each Thessian polygon assigned to the site.

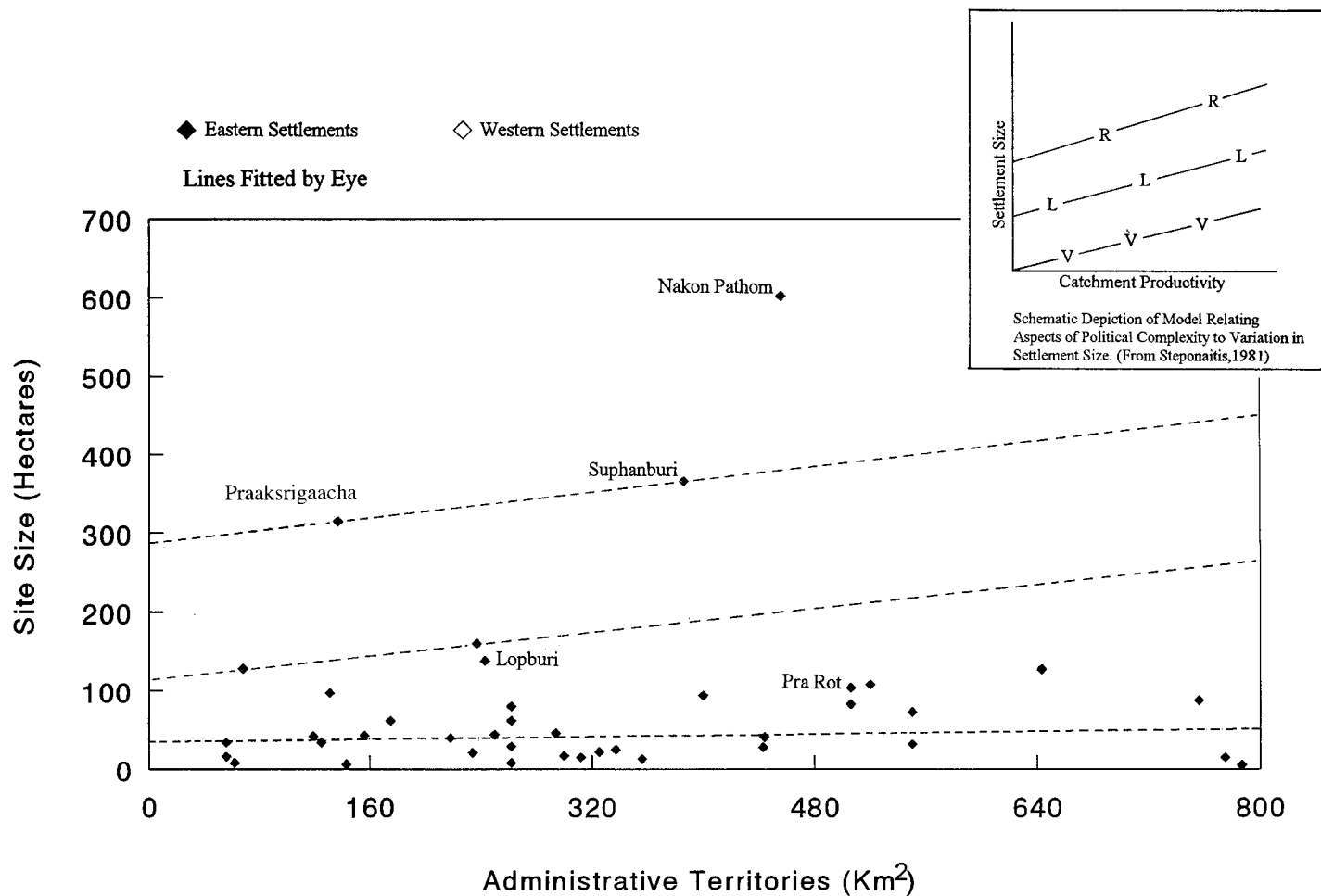


FIG. 7. Land suitable for wet rice cultivation associated with moated settlements in central Thailand.

The results are suggestive, although the lack of detailed information about the agricultural regime and non-moated sites in each administrative area does not allow for detailed conclusions. The size of each community graphed against area of individual administrative territories produces several levels of separation, in concordance with Steponaitis' model. The regional centers, however, produced two levels of separation, based on the wide range of site sizes for this administrative category. Nakhon Pathom is in its expected place, as the polity capital, but the very large moated sites are significantly larger than the large and medium regional capitals. The distribution of the very large moated sites may conform to the predictions of Steponaitis' model if these sites held an administrative position that was specific to them alone. There are several other explanations possible for this configuration. Rather than representing a supra-regional center level of administration, these sizes may be a historical artifact of previous capital status for these communities. More information about the history of this region is necessary to test this proposition.

It is possible that one of the assumptions concerning catchment productivity has been violated. For the purposes of this study I have assumed that the agricultural potential is the same on both sides of the Bay of Bangkok. This may not be a valid assumption, as different cultivation practices can alter the agricultural potential of a given plot of land. Lower rainfall on the western side of the Central Plain may have promoted greater water control, and transplanting regimes rather than broadcast rice growing systems. Increased productivity could account for larger site sizes. It is possible that the agricultural potential on the east and west sides of the Central Plain is different and that combining these data has produced an artificially

inflated number of levels in the administrative hierarchy.

Emergence of Complex Politics on the Central Plain of Thailand

Settlement distribution and the ranked sizes of the settlements suggest that by the end of the first millennium A.D. the Central Plain of Thailand was integrated into a single polity, but the processes involved in the development of a centralized administrative hierarchy remain unelucidated. While basal deposits at several sites have yielded evidence of earlier occupations and demonstrate that there was proto-historic habitation of the Central Plain of Thailand (Bronson 1976; Ciarla 1992), little is known about the history of the region between about 500 B.C. and the sixth century A.D.

Examination of the distribution of moated settlements that show evidence of having extended their moats, discernibly increasing site size, provides evidence about processes of regional integration. The eight settlements are not randomly distributed throughout the Central Plain. Five of these settlements are either the capital for the respective administrative region or the nearest neighbor for one of these capitals.

In the Prachinburi region, Ku Muang (2.1) shows evidence of expansion from 4.5 to 41 ha and is the closest settlement to the capital of Pra Rot (9.2). In Uthai Thani, Muang Bon (8.2) increased from 8 to 61 ha. In Nakhon Sawan, Sra Gao (8.5) grew from 25 to 45 ha. The association of settlements with evidence of site expansion and regional capitals suggests that there was political or economic competition between the settlements.

Although the Lopburi administrative region includes a settlement with evidence of enlargement, this site is not the nearest neighbor of the capital. Utapao (12.1) is situated approximately halfway

between the regional capitals of Lopburi and Pra Rot. It increased from 15 to 83 ha when the second moat was added. Its location halfway between Lopburi and Pra Rot and history of moat expansion suggest that Utapao may have controlled a regional territory. Utapao may have been the regional center for a separate regional administrative unit which was eventually incorporated into the Lopburi administrative hierarchy. Dating the moat expansion at Utapao in relation to the growth of Lopburi and Pra Rot would shed light on this issue.

Praaksrigacha (3.2) increased in size from 81 to 315 ha. Praaksrigacha, Suphanburi, and Nakhon Pathom are the three largest sites in the settlement hierarchy. Before Nakhon Pathom doubled in size through addition of the second moat, it was the same size as the other two settlements, about 300 ha. If these settlements were the same size concurrently, they may have been the regional centers of competing polities. The doubling of moat size at Nakhon Pathom may signal supra-regional integration of settlements.

The remaining two settlements with evidence of moat expansion are Sites 16.2 and 4.3, in the northwest and southeast margins of the Central Plain, respectively. Both were classified as "special function sites" placed either to control trade or to extract and protect special resources. The expansion of these sites may signify increasing control over settlements on the margins of administrative territories.

The expansion of the five regional capitals or their nearest neighbors suggests that competitive interactions characterized the time period immediately prior to regional integration. This proposition can be tested by dating the moat expansions of nearest neighbors in relation to growth of capitals. There is also some textual evidence to suggest that regional integration occurred. Research on the Dvaravati Kingdom identified a capital first at the

site of Utong (13.2) and later at Nakhon Pathom (7.3) (Higham 1989:279). The designation of Utong as a capital is based on the recovery of inscriptions during excavation of public buildings. A copper plate was recovered that, translates, states "Sri Harsavarman, grandson of Isanavarman, having expanded the sphere of his glory, obtained the Lion Throne through regular succession" (Higham 1989:271). This suggested to early researchers that a royal household was maintained at Utong. The present study, which relies solely on moated settlement size as the organizing variable, assigns Utong to the position of district center. Its position in the administrative hierarchy would suggest that it was no more than a minor center by the 10th century. The presence of this copper plate at Utong, rather than signifying a position as a capital, may actually indicate loss of administrative autonomy and incorporation into a regional system.

The growth of Praaksrigacha may signal the emergence of supra-regional organization. If Praaksrigacha, Suphanburi, and Nakhon Pathom were all approximately the same size at the same time, there may have been intense competition. That Nakhon Pathom came away the victor may be indicated by moat extension to become the largest settlement on the Central Plain.

The five largest settlements, Nakhon Pathom, Suphanburi, Praaksrigacha, Site 10.4, and Site 13.7, are located on the western side of the Bay of Bangkok. This ability to support higher urban population densities may be due to one or a combination of several factors. One possibility is that urban settlements are older on the western side of the plain, and the observed population density is the accumulation of an extended period of habitation. This pattern of settlement distribution may be an artifact of occupational duration.

A second possibility is that transplanted wet rice agriculture was practiced on the

western side of the Bangkok Plain, providing an agricultural base for higher population densities. Examination of non-moated and moated settlement patterns in Lopburi Province suggests that broadcast wet rice was the most common mode of agricultural production on the eastern side during this time period.

A third possibility is that polities on the western side of the Central Plain derived material support for urban populations through other activities besides agriculture, specifically long-distance trade. The limited evidence available suggests that the Central Plain has had extensive involvement with goods moving through Southeast Asia. Excavations at the cemetery site of Ban Don Tha Pet (Glover 1990), dated to the fourth century B.C., have yielded carnelian and glass beads from India, high-tin bronzes that were probably export objects to India, and double-headed ear ornaments from Viet Nam. The site is located on the western side of the Central Plain and suggests that goods moved through the Central Plain, possibly coming over the Three Pagoda Pass from the Gulf of Martaban.

In the early centuries A.D. communities on the Central Plain were in contact with polities in the Mekong delta. Stylistic similarities between artifacts excavated at Oc Eo in southern Viet Nam (Malleret 1959) and objects found at Chansen (Bronson 1976) indicate that communities on the Central Plain were tied economically, if not politically, to Mekong settlements. These items include earthenware stamps, bronze bells with filigree spirals, and tin stamps (Bronson 1976:682). The presence of similar objects in communities separated by hundreds of kilometers suggests that their relationship facilitated the exchange of goods and/or technologies. Wheatley (1983) suggests that the conquered polities of "Tungsung" were on the shores of the Bay of Bangkok and

that these moated settlements were subordinate to a polity or polities in the Mekong Delta, collectively known as Funan.

Funan's emergence in the second century A.D. appears to have been tied to long-distance trade (Hall 1985). The Mekong Delta was an important node in an international trade network which included the Mediterranean, India, Southeast Asia, and China. Goods moved in both directions from southern Europe (Miller 1969) and China (Wolters 1967), through east Africa (Dato, 1970, Wright 1993), and India (Ray 1989a, 1989b), to Southeast Asia (Mabbett 1977; Ardika and Bellwood 1991). Excavations at Oc Eo in southern Vietnam, which was probably an important Funan port, yielded objects as diverse as intaglios from the Roman Empire and mirrors from the Han Chinese Empire (Malleret 1959).

Funan declined in the late fifth century A.D. Hall (1985:72) suggests that, as wet rice agriculture spread throughout island Southeast Asia, the Mekong delta lost its monopoly as a supplier of surplus rice. Wolters (1967:37) argues that Funan collapsed as a result of Khmer pressure from the north. In addition, trade routes appeared to have shifted, depriving Funan coastal ports of their economic base. Ships, now capable of sailing both legs of the route between China and India, began to use the Straits of Mollucca rather than off-loading at the northern end of the Malay Peninsula.

Trade with India may have been an important source of revenue for communities on the western side of the Bay of Bangkok during the second half of the first millennium A.D. This proposition has yet to be tested through systematic examination of foreign goods in moated settlements or facilities for storage. The goods and services provided by the moated settlements, likewise, have not been identified. Control of trade, however, may be a

key element in explanation of the distribution of sites on Central Plain.

CONCLUSIONS

Through analysis of locational data pertaining to moated sites in Central Thailand, this study has begun to assess the degree of socio/political and economic integration of settlements around the Bay of Bangkok during the second half of the first millennium A.D. The study addresses a paucity of information about an important time period in the development of complex polities in Southeast Asia. The lack of systematic collection of data pertaining to this time period may be partially attributed to the history of investigation in the region; historians have been concerned with time periods with written records, and archaeologists have been pre-occupied with origin questions centering on topics such as plant domestication and the development of metallurgy.

Consideration of the patterns of moating at settlements around the Bay of Bangkok suggests that the moats may be used to signify the presence of supra-site administrative functions. The proposition that moated settlements were administrative nodes was approached through examination of the relationship between site size and catchment, under conditions of broadcast and wet rice agriculture. Bayard, rightly, questions "the degree to which we are currently able to assign values of any precision to the variables of food production and population density often put forth as crucial causal ones for increasing complexity" (1992:18). In a critique of studies of population density, agricultural productivity, and site size, he notes that the lack of precision and the wide range of variation in estimates of these variables limit their explanatory power. He concludes, however, that "we must continue to apply these tests, even with imprecise values for our variables, if

only to point up errors in our prior assumptions; but the inadequacies of our database must be continually borne in mind" (Bayard 1992:24).

Keeping this caution in mind, estimates of the maximum amount of broadcast wet rice available for consumption within a circular area with a radius of 2 km on the Central Plain suggest that the largest that a self-sustaining community could grow was about 10 ha. It is unlikely that, under conditions of broadcast wet rice agriculture, moated settlements larger than 10–12 ha were self-supporting, but drew on other communities' resources. If using transplanted wet rice, self-supporting sites could, theoretically, grow to up to 70 ha in size. The appearance of larger moated settlements, therefore, indicates the presence of regional control, as these communities had to mobilize resources from other settlements. Comparison of sizes of non-moated settlements from both sides of the Central Plain, identified through systematic regional surveys, will provide a basis for assessing types of agriculture practiced. Establishing dates for the appearance of settlements larger than the maximum predicted for the type of agriculture practiced should also date the inception of supra-settlement mobilization strategies.

A hierarchy of site sizes suggests that they represent at least four administrative levels. This hierarchy is based on only one variable: size of moated settlements. Systematic examination of other site attributes, such as presence of ramparts and public buildings, may change ranking in the administrative hierarchy. It is also necessary to investigate the extent of moated settlements in the Upper Chao Phraya Valley to determine the geographical limits of the Dvaravati polities.

Although the presence of a moated settlement that is almost twice as large as the next largest settlement suggests that the region was integrated into a single polity by

the end of the time period considered here, the process by which integration was achieved and identification of the number of extant polities await further research. Depending on the scale of the investigation, patterns observed in the limited data available here fit criteria for single state-level polity, a series of competitive states, or some form of non-state organization, such as complex chiefdoms. Depending on the time period, all three social formations may have have functioned around the Bay of Bangkok. The rank-size distribution of maximum settlement sizes suggests, however, that, by the end of the time period under consideration here, the Central Plain was integrated into one regional economic system. Further investigation, specifically refinement of regional chronology of growth of individual settlements, is needed to identify relevant processes in the development of complex polities.

The regional areas, as defined here, fit the definition of peer polities (Renfrew 1975; Renfrew and Cherry 1986) in that the five complete regions are approximately the same size and exhibit a shared system of writing, beliefs, language, and political institutions. These shared features came about through interactions, although the precise nature of these interactions will only be known when more precise chronologies are available for Dvaravati sites. The presence of the moats and the evidence for ramparts on sites in the Central Plains suggest that competition and warfare may have been one type of interaction that took place. Further investigations of moated settlements and associated territories within the framework of peer polity interactions may be a useful way to approach the development of social systems around the Bay of Bangkok.

Despite the present inability to provide labels for the social phenomena examined here, there has been a conscious effort to characterize these manifestations of social and political integration with reference to

terms used by anthropologists in other parts of the world. While terms such as "mandala" (Higham 1989), "muang" Bayard (1992), and "ban" (Moore 1988a) acknowledge unique features of Southeast Asian polities, they deprive anthropologists of ways to make meaningful comparisons with other case studies and diminish explanatory power in elucidating origins of these social complexes. The use of these terms reinforces the perceptions that Southeast Asian prehistory and early history is unique and cannot be elucidated in terms of universal models.

The lack of a suitable database for testing propositions about the origins and organization of early complex polities may partially account for views in the literature that social development in Southeast Asia does not follow trajectories described for other areas. In addition to adequate databases for testing hypotheses, explanatory models are needed that address the emergence of complex polities within the context of interactions with other complex polities, circumstances that are especially prevalent in Southeast Asia. The use of models developed to address questions of emergence of pristine states, as opposed to polities that are in extended contact with other polities, may also have contributed to the perception that Southeast Asia is unique in its development (Morrison 1994:183).

Investigating political formations that were also in extensive contact with other polities on the western side of the Indian Ocean, Wright notes that "any general explanation of the development of complex cultural systems should subsume cases arising under many different conditions" (Wright 1993:658). The quantification of variables for characterization of degree of regional organization and economic organization is a key step in the development and testing of explanatory models which, while specific to the Central Plain of Thailand, are of relevance to understanding other social systems as well.

APPENDIX I: SIZES AND ASSOCIATED AREAS OF MOATED SETTLEMENTS
ON THE CENTRAL PLAIN OF THAILAND

Number ^a	Name	Phase 1 site size (ha)	Phase 2 site size (km ²)	Associated lands
Chainat				
3.1	Praaksrigacha Utapao	20.8	20.8	243
3.2		81	315	137
3.3		40.2	40.2	218
3.4		14.5	14.5	312
3.5		8.3	8.3	62
3.6	Chansen			131
8.3		8	8	262
8.7		32	32	550
13.6		14.8	14.8	775
13.9		22	22	262
14.1	Kumuang	62	62	175
14.2		44	44	250
15.2	Garung	11	11	0
16.1		13.8	13.8	0
Lopburi				
11.1	Lopburi	137.5	137.5	243
11.2	Prom Tin Tai	21.5	21.5	325
11.3	Tannon Yai	27	27	65
11.4	Kok Samrong	43	43	156
11.5	Dom Marum	42	42	119
11.6	Mai Pai Sali	16.4	16	56
11.7	KS 53	10	10	0
11.8	Tha Kae	70	70	65
12.1	Utapao	15.3	83	506
12.2	Kitkin	28	28	443
12.3		13.2	13.2	356
14.3		80	80	262
14.4		29	29	262
Nakhon Pathom				
1.1	Ban Paeng Tuk	161	161	768
5.1	Petburi			0
7.1				556
7.2	Kampaengsang Nakhon	71	71	300
7.3	Pathom	300	602	456
9.3	Ratburi Ku Bua	1.3	1.3	0
10.1		94	94	400
10.3		160	160	237
10.4		127	127	643

APPENDIX—*Continued*

Number ^a	Name	Phase 1 site size (ha)	Phase 2 site size (km ²)	Associated lands
Nakhon Sawan				
8.5	Sra Gao	25	45	81
8.6		1	1	
8.8	Kok Prassat	79	79	
8.9	Bra Kam	2.1	2.1	119
8.10	Apaisali	10.2	10.2	94
8.11		36	36	119
Prachinburi				
2.1	Ku Muang	4.45	41	444
4.2	Muang Pra Rot	108	108	520
4.3		12	34	56
6.1	Don Lakon	25	25	337
9.1				1381
9.2	Pra Rot	103.7	103.7	506
Suphanburi				
13.1	Sragrajom			312
13.2	Utong	73.3	73.3	550
13.3		6	6	143
13.4		88	88	756
13.5				356
13.7		128	128	68
13.8		366	366	386
13.10		4.9	4.9	787
15.1		46	46	294
Uthai Thani				
8.2	Muang Bon	8	61	343
8.4		18.7	18.7	138
16.2		14	83	
16.3	Ban Kua	39.6	39.6	905
16.4	Ban Dai	84	84	556

^a The number system in Supajanya and Vanasin (1983) was preserved in this study to enable the interested reader to compare this analysis with the original study.

**APPENDIX II: SIZES AND
ASSOCIATED AREAS OF
NON-MOATED DVARAVATI
SETTLEMENTS IN LOPBURI
PROVINCE, THAILAND
(from Mudar 1993)**

Site No. ^a	Site size (ha)	Associated lands (km ²)
KS 29	12.1	235
KS 53	10.0	188
KS 71	.50	136
KS 75	.64	235
KS 92	1.0	115
KS 97	3.3	115
KS 102	2.4	2.5
KS 120	5.5	157
KS 154	.10	314
KS 155	1.4	224
KS 156	5	156
KS 159	.4	186
KS 160	3.7	235
KS 163	2	300
KS 165	2	143
KS 166	1	156
KS 167	2.5	104
KS 168	1	157
KS 169	3.3	188
KS 170	5.6	136
KS 171	3.8	45
KS 172	1.3	104
KS 173	.40	175

^a The number system, Kok Samrong Survey, from Mudar (1993) is retained here.

ACKNOWLEDGMENTS

The impetus for this study grew out of settlement survey research in Thailand in 1989–1990. This project was supported by the Wenner Gren Foundation for Anthropological Research and a Department of Education Fulbright Grant. I thank several Thai scholars who were instrumental in collection of data for this study. Acharn Surapol Natapintu and Acharn Rasmi Shoocondej loaned Thai studies of moated settlements and facilitated my understanding of the materials. Acharn Phutorn Bhumaton showed me many of the moated settlements in Lopburi Province. I also thank Dr. Henry Wright for his continued interest in this project, and an anonymous reviewer for comments. Maps and graphics were provided by Mr. Stuart Speaker, Mr. Gervaise Pursell, and Ms. Marcia Bakry. This paper was originally presented as part of an invited session, "Land-

scapes of Power: Regional Perspectives on States in Asia," held at the 92nd Annual Meeting of the American Anthropological Association in Washington, DC (1993).

REFERENCES CITED

- Ardika, I. W., and P. Bellwood
1991 Sembiran: The beginning of Indian contact with Bali. *Antiquity* 65:221–232.
- Bayard, Donn
1992 Models, scenarios, variables and suppositions: Approaches to the rise of social complexity in mainland Southeast Asia, 700BC–500 AD. In *Early Metallurgy, Trade, and Urban Centres in Thailand and Southeast Asia*, edited by I. Glover, P. Suchitta, and J. Villiers, pp. 13–38. White Lotus Co., Bangkok.
- Briggs, L. P.
1951 *The Ancient Khmer Empire*. Transactions of the American Philosophical Society, No. 41.
- Bronson, Bennet
1976 *Excavations at Chansen and the Cultural Chronology of Proto-historic Central Thailand*. Ph.D. dissertation, University of Pennsylvania, Philadelphia.
- Ciarla, Roberto
1992 The Thai–Italian Lopburi Regional Archaeological Project: Preliminary results. In *Southeast Asian Archaeology 1990*, edited by I. Glover, pp. 111–128. Centre for South-East Asian Studies, University of Hull, England.
- Christie, Jan Wisseman
1990 Trade and state formation in the Malay Peninsula and Sumatra, 300 B.C.–A.D. 700. In *The Southeast Asian Port and Polity*, edited by J. Kathirithamby-Wells and John Villiers, pp. 39–60. Singapore Univ. Press.
- Coedes, Georges
1937– *Inscriptions du Cambodge*. Ecole Francaise
1954 d'Extreme Orient, Hanoi/Paris.
1968 *The Indianized States of Southeast Asia*. East-West Centre Press, Honolulu.
- Datoo, B. A.
1970 Rhapta: The location and importance of East Africa's first port. *Azania* 5:65–75.
- De Casparis, J. G.
1979 *Palaeography as an auxiliary discipline in research on early Southeast Asia*. In *Early South East Asia*, edited by R. B. Smith and W. Watson, pp. 380–394. Oxford Univ. Press, Oxford.

Durrenberger, E. P.

- 1978 *Agricultural Production and Household Budgets in a Shan Peasant Community in Northwestern Thailand*. Ohio University Center for International Studies, Athens.

Glover, Ian

- 1982–1985 Archaeological Survey in west-central Thailand: A second report on the 1982–1983 field season. *Asian Perspectives* 25:83–109.
1990 *Early Trade between India and Southeast Asia: A Link in the Development of a World Trading System*. University of Hull Center for Southeast Asian Studies, Hull, England.

Hagesteijn, Rene

- 1989 *Circle of Kings: Political Dynamics in Early Continental Southeast Asia*. Foris, Providence, RI.

Hall, Kenneth R.

- 1985 *Maritime Trade and State Development in Early Southeast Asia*. Univ. of Hawaii Press, Honolulu.

Hanks, Lucius M.

- 1972 *Of Rice and Men: Agricultural Ecology in Southeast Asia*. Aldine Press, Chicago.

Higham, Charles F.

- 1989 *The Archaeology of Mainland Southeast Asia*. Cambridge Univ. Press, Cambridge, England.

Hodder, Ian, and Clive Orton

- 1976 *Spatial Analysis in Archaeology*. Cambridge Univ. Press, Cambridge, England.

Indrawooth, Phasook

- 1985 *Index Pottery of the Dvaravati Period*. Department of Archaeology, Silpakorn University, Bangkok, Thailand.

Izikowitz, K. G.

- 1951 *Lamet: Hill Peasants in French Indochina*. Etnologiska Studier 17. Etnografiska Museet, Goteborg.

Johnson, Gregory A.

- 1981 Monitoring complex system integration and boundary phenomenon with settlement size data. In *Archaeological Approaches to the Study of Complexity*, edited by S. E. Van der Leeuw, pp. 143–188. Universiteit van Amsterdam, Amsterdam.

Krairiksh, P.

- 1975 *Chula Pathom Cedi: Architecture and Sculpture of the Dvaravati Period*. Ph.D. dissertation, Harvard University, Cambridge, MA.

Lyons, Elisabeth

- 1979 Dvaravati: A consideration of its formative period. In *Early South East Asia*, edited by R. B. Smith and W. Watson, pp. 352–59. Oxford Univ. Press, Oxford, England.

Mabbett, I. W.

- 1977 The 'Indianization' of Southeast Asia: Reflections on the historical sources. *Journal of Southeast Asian Studies* 8:143–161.

Macdonald, W. K.

- 1980 *Some Implications of Societal Complexity: Organizational Variability at Non Nok Tha, Thailand (2000–0 B.C.)*. Ph.D. dissertation, University of Michigan, Ann Arbor.

Malleret, L.

- 1959 *L'Archaeologie du Delta du Mekong*. Ecole Francaise d'Extreme Orient, Paris.

Miksic, John

- 1995 Evolving archaeological perspectives on Southeast Asia, 1970–95. *Journal of Southeast Asian Studies* 26(1):46–62.

Miller, J. I.

- 1969 *The Spice Trade of the Roman Empire*. Oxford Univ. Press, Oxford, England.

Moore, Elizabeth

- 1988a *Moated Settlements in Early Northeast Thailand*. British Archaeological Reports (International Series) No. 400, Oxford, England.
1988b Notes on two types of moated settlements in Northeast Thailand. *Journal of the Siam Society* 76:275–287.

Morrison, Kathleen D.

- 1994 States of the theory and states of Asia: Regional perspectives on states in Asia. *Asian Perspectives* 33(2):183–196.

Mudar, Karen

- 1993 *Prehistoric and Early Historic Settlements on the Central Plain: Analysis of Archaeological Survey in Lopburi, Thailand*. Ph.D. dissertation, University of Michigan, Ann Arbor.
1995 Evidence for prehistoric dryland farming in mainland Southeast Asia: Results of regional survey in Lopburi Province, Thailand. *Asian Perspectives* 34(2):157–194.

Naroll, R.

- 1962 Floor area and settlement patterns. *American Antiquity* 27:587–589.

O'Connor, Richard A.

- 1995 Agricultural change and ethnic succession in Southeast Asian States: A case for regional anthropology. *Journal of Asian Studies* 54(4):968–996.

Pelliot, P.

- 1904 Deux itinéraires de Chine en Inde à la fin du VIII^e siècle. *Bulletin de l'Ecole Française d'Extreme Orient* 4:131–413.

Quaritch-Wales, H. G.

- 1969 *Dvaravati: The Earliest Kingdom of Siam*. Bernard Quaritch, London.

Ray, Himanshu

- 1989a Early historical trade: An overview. *The Indian Economic and Social History Review* 26: 437–458.
- 1989b Early maritime contacts between South and Southeast Asia. *Journal of Southeast Asian Studies* 20:42–54.

Renfrew, Colin

- 1975 Trade as action at a distance: Questions of integration and communication. In *Ancient Civilization and Trade*, edited by Jeremy Sabloff and C. C. Lamberg-Karlovsky, pp. 3–59. Univ. of New Mexico Press.

Renfrew, Colin, and John Cherry

- 1986 *Peer Polity Interaction and Socio-political Change*. Cambridge Univ. Press, Cambridge, England.

Saraya, Dhida

- 1992 *The hinterland state of Sri Thep Sri Dva: A reconsideration*. In *Early Metallurgy, Trade, and Urban Centres in Thailand and Southeast Asia*, edited by I. Glover, P. Suchitta, and J. Villiers, pp. 131–143. White Lotus Co., Bangkok.

Steponaitis, Vincas P.

- 1981 Settlement hierarchies and political complexity in nonmarket societies: The Formative Period of the Valley of Mexico *American Anthropologist* 85:320–365.

Stott, Philip

- 1992 Angkor: Shifting the hydraulic paradigm. In *The Gift of Water: Water Management, Cosmology and the State in Southeast Asia*, edited by J. Rigg, pp. 47–58. School of Oriental and African Studies, University of London.

Supajanya, T., and P. Vanasin

- 1983 *The Inventory of Ancient Settlements in Thailand*. Toyota Foundation, Bangkok.

Thai Fine Arts Department

- 1988 *Archaeology of Thailand*, Part 2. Division of Archaeology, Fine Arts Department, Bangkok.

Vallibhotama, Srisakra

- 1986 Political and cultural continuities at Dvaravati sites. In *Southeast Asia in the 9th to 14th Centuries*, edited by David G. Marr and A. C.

Milner, pp. 229–238. Institute of Southeast Asian Studies, Singapore.

- 1992 Early urban centers in the Chao Phraya Valley of Central Thailand. In *Early Metallurgy, Trade, and Urban Centres in Thailand and Southeast Asia*, edited by I. Glover, P. Suchitta, and J. Villiers, pp. 123–130. White Lotus Co., Bangkok.

Watabe, Tadayo

- 1976 The glutinous rice zone in Thailand: Patterns of change in cultivated rice. In *Southeast Asia: Nature Society and Development*, edited by S. Ichimura, pp. 96–113. Univ. Press of Hawaii, Honolulu.

Weiss, Kenneth M.

- 1973 *Demographic Models for Anthropology*. Memoirs of the Society for American Archaeology No. 27. Washington, DC.

Welch, David

- 1985 *Adaptation to Environmental Unpredictability: Agricultural Intensification and Regional Exchange at Late Prehistoric Centers in the Phimai Region, Thailand*. Ph.D. dissertation, University of Hawaii, Honolulu.

Wheatley, P.

- 1983 *Nagara and Commandery*. The University of Chicago Department of Geography Research Papers 207–208.

Wolters, O. W.

- 1967 *Early Indonesian Commerce: A Study of the Origins of Srivijaya*. Cornell Univ. Press, Ithaca, NY.
- 1982 *History, Culture, and Region in Southeast Asian Perspectives*. Institute for Southeast Asian Studies.

Wright, H. T.

- 1977 Recent research on the origin of the state. *Annual Review of Anthropology* 6:379–397.
- 1993 Trade and politics on the Eastern Littoral of Africa, A.D. 800–1300. In *Archaeology in Africa*, edited by Thurstan Shaw, Paul Sinclair, Bassey Andah, and Alex Okpoko, pp. 658–671. One World Archaeology, Routledge, London.